General

Guideline Title

BTS/ICS guideline for the ventilatory management of acute hypercapnic respiratory failure in adults.

Bibliographic Source(s)

Davidson AC, Banham S, Elliott M, Kennedy D, Gelder C, Glossop A, Church AC, Creagh-Brown B, Dodd JW, Felton T, FoÃ«x B, Mansfield L, McDonnell L, Parker R, Patterson CM, Sovani M, Thomas L. BTS/ICS guideline for the ventilatory management of acute hypercapnic respiratory failure in adults. Thorax. 2016 Apr;71 Suppl 2:ii1-ii35. [300 references] PubMed

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Regulatory Alert

FDA Warning/Regulatory Alert

Note from the National Guideline Clearinghouse: This guideline references a drug(s) for which important revised regulatory and/or warning information has been released.

August 31, 2016 – Opioid pain and cough medicines combined with benzodiazepines : A U.S. Food and Drug Administration (FDA) review has found that the growing combined used of opioid medicines with benzodiazepines or other drugs that depress the central nervous system (CNS) has resulted in serious side effects, including slowed or difficult breathing and deaths. FDA is adding Boxed Warnings to the drug labeling of prescription opioid pain and prescription opioid cough medicines and benzodiazepines.

Recommendations

Major Recommendations

The levels of evidence (1++, 1+, 1-, 2++, 2+, 2-, 3, 4), grades of recommendations (A-D), and good practice points are defined at the end of the "Major Recommendations" field.

Principles of Mechanical Ventilation

Modes of Mechanical Ventilation

Recommendation

Pressure-targeted ventilators are the devices of choice for acute non-invasive (positive pressure) ventilation (NIV) (Grade B).

Good Practice Points

Both pressure support (PS) and pressure control modes are effective.
Only ventilators designed specifically to deliver NIV should be used.

Choice of Interface for NIV

Recommendation

A full face mask (FFM) should usually be the first type of interface used (Grade D).

Good Practice Points

A range of masks and sizes is required and staff involved in delivering NIV need training in and experience of using them.
NIV circuits must allow adequate clearance of exhaled air through an exhalation valve or an integral exhalation port on the mask.

Indications for and Contra-indications to NIV in Acute Hypercapnic Respiratory Failure (AHRF)

Recommendation

The presence of adverse features increases the risk of NIV failure and should prompt consideration of placement in high dependency unit (HDU)/intensive care unit (ICU) (Grade C).

Good Practice Points

Adverse features should not, on their own, lead to withholding a trial of NIV.
The presence of relative contra-indications necessitates a higher level of supervision, consideration of placement in HDU/ICU and an early appraisal of whether to continue NIV or to convert to invasive mechanical ventilation (IMV).

Monitoring during NIV

Good Practice Points

Oxygen saturation should be continuously monitored.
Intermittent measurement of partial pressure of carbon dioxide (pCO_2) and pH is required.
Electrocardiogram (ECG) monitoring is advised if the patient has a pulse rate >120 bpm or if there is dysrhythmia or possible cardiomyopathy.

Supplemental Oxygen Therapy with NIV

Recommendations

Oxygen enrichment should be adjusted to achieve oxygen saturation (SaO_2) 88% to 92% in all causes of AHRF treated by NIV (Grade A).
Oxygen should be entrained as close to the patient as possible (Grade C).

Good Practice Points

As gas exchange will improve with increased alveolar ventilation, NIV settings should be optimised

before increasing the fractional inspired concentration of oxygen (FiO_2).

The flow rate of supplemental oxygen may need to be increased when ventilatory pressure is increased to maintain the same SaO_2 target.

Mask leak and delayed triggering may be caused by oxygen flow rates >4 L/min, which risks promoting or exacerbating patient-ventilator asynchrony. The requirement for high flow rates should prompt a careful check for patient-ventilator asynchrony.
A ventilator with an integral oxygen blender is recommended if oxygen at 4 L/min fails to maintain SaO_2 >88%.

Humidification with NIV

Recommendation

Humidification is not routinely required (Grade D).

Good Practice Point

Heated humidification should be considered if the patient reports mucosal dryness or if respiratory secretions are thick and tenacious.

Bronchodilator Therapy with NIV

Good Practice Points

Nebulised drugs should normally be administered during breaks from NIV.
If the patient is dependent on NIV, bronchodilator drugs can be given via a nebuliser inserted into the ventilator tubing.

Sedation with NIV

Recommendations

Sedation should only be used with close monitoring (Grade D).
Infused sedative/anxiolytic drugs should only be used in an HDU or ICU setting (Grade D).
If intubation is not intended should NIV fail, then sedation/anxiolysis is indicated for symptom control in the distressed or agitated patient (Grade D).

Good Practice Point

In the agitated/distressed and/or tachypnoeic individual *on NIV*, intravenous morphine 2.5–5 mg (± benzodiazepine) may provide symptom relief and may improve tolerance of NIV.

NIV Complications

Good Practice Points

Minor complications are common but those of a serious nature are rare. Patients should be frequently assessed to identify potential complications of NIV.
Care is needed to avoid overtightening of masks.
Previous episodes of ventilator-associated pneumothorax warrant consideration of admission to HDU/ICU and use of NIV at lower than normal inspiratory pressures.
The development of a pneumothorax usually requires intercostal drainage and review of whether to continue with NIV.

Sputum Retention

Recommendations

In patients with neuromuscular disease (NMD), mechanical insufflation and exsufflation should be used, in addition to standard physiotherapy techniques, when cough is ineffective and there is

sputum retention (Grade B).
Mini-tracheostomy may have a role in aiding secretion clearance in cases of weak cough (NMD/chest wall disease [CWD]) or excessive amounts (chronic obstructive pulmonary disease [COPD], cystic fibrosis [CF]) (Grade D).

Modes of IMV

Recommendations

Spontaneous breathing should be established as soon as possible in all causes of AHRF (Grade C).
Controlled IMV may need to be continued in some patients due to severe airflow obstruction, weak muscles leading to poor triggering or to correct chronic hypercapnia (Grade C).

Good Practice Point

In obstructive diseases, controlled IMV should be continued until airway resistance falls.

Invasive Ventilation Strategy

Recommendations

During controlled ventilation, dynamic hyperinflation should be minimised by prolonging expiratory time (Inspiratory/expiratory time [I:E] ratio 1: 3 or greater) and setting a low frequency (10–15 breaths/min) (Grade C).
Permissive hypercapnia (aiming for pH 7.2–7.25) may be required to avoid high airway pressures when airflow obstruction is severe (Grade D).
Carbonic anhydrase inhibitors should not be routinely used in AHRF (Grade C).

Positive end Expiratory Pressure

Recommendation

Applied extrinsic positive end expiratory pressure (ePEEP) should not normally exceed 12 cm (Grade C).

Sedation in IMV

Recommendation

Sedation should be titrated to a specific level of alertness (Grade B).

Patient-Ventilator Asynchrony

Recommendations

Ventilator asynchrony should be considered in all agitated patients (including NIV) (Grade C).
As patients recover from AHRF, ventilator requirements change and ventilator settings should be reviewed regularly (Grade C).

Use and Timing of a Tracheostomy

Recommendations

Performing routine tracheostomy within 7 days of initiating IMV is not recommended (Grade A).
The need for and timing of a tracheostomy should be individualised (Grade D).

Good Practice Points

In AHRF due to COPD, and in many patients with NMD or obesity hypoventilation syndrome (OHS), NIV supported extubation should be employed in preference to inserting a tracheostomy.
In AHRF due to NMD, alongside discussion with the patient and carers, the decision to perform tracheostomy should be multidisciplinary and should involve discussion with a home ventilation unit.

Management of Hypercapnic Respiratory Failure

Prevention of AHRF in Acute Exacerbation of COPD (AECOPD)

Recommendation

In AHRF due to AECOPD controlled oxygen therapy should be used to achieve target saturations of 88% to 92% (Grade A).

Good Practice Points

Controlled oxygen therapy should be used to achieve a target saturation of 88% to 92% in ALL causes of AHRF.

Role of NIV in AECOPD

Recommendations

For most patients with AECOPD, the initial management should be optimal medical therapy and targeting an oxygen saturation of 88% to 92% (Grade A).
NIV should be started when pH <7.35 and pCO_2 >6.5 kPa persist or develop despite optimal medical therapy (Grade A).
Severe acidosis alone does not preclude a trial of NIV in an appropriate area with ready access to staff who can perform safe endotracheal intubation (Grade B).
The use of NIV should not delay escalation to IMV when this is more appropriate (Grade C).
The practice of NIV should be regularly audited to maintain standards (Grade C).

Starting NIV in COPD

Good Practice Points

Arterial blood gas (ABG) measurement is needed prior to and following starting NIV.
Chest radiography is recommended but should not delay initiation of NIV in severe acidosis.
Reversible causes for respiratory failure should be sought and treated appropriately.
At the start of treatment, an individualised patient plan (involving the patient wherever possible) should document agreed measures to be taken in the event of NIV failure.

Prognostic Features Relating to Use of NIV in COPD

Recommendations

Advanced age alone should not preclude a trial of NIV (Grade A).
Worsening physiological parameters, particularly pH and respiratory rate (RR), indicate the need to change the management strategy. This includes clinical review, change of interface, adjustment of ventilator settings and considering proceeding to endotracheal intubation (Grade A).

Good Practice Point

If sleep-disordered breathing pre-dates AHRF, or evidence of it complicates an episode, the use of a controlled mode of NIV overnight is recommended.

Duration of NIV in COPD

Recommendation

NIV can be discontinued when there has been normalisation of pH and pCO_2 and a general improvement in the patient's condition (Grade B).

Good Practice Points

Time on NIV should be maximised in the first 24 h depending on patient tolerance and/or

complications.
NIV use during the day can be tapered in the following 2 to 3 days, depending on pCO_2 self-ventilating, before being discontinued overnight.

Optimising NIV Delivery and Technical Considerations

Good Practice Point

Before considering NIV to have failed, always check that common technical issues have been addressed and ventilator settings are optimal (see Table 3 in the original guideline document).

Indications for IMV in AECOPD

Recommendations

IMV should be considered if there is persistent or deteriorating acidosis despite attempts to optimise delivery of NIV (Grade A).
Intubation should be performed in respiratory arrest or peri-arrest unless there is rapid recovery from manual ventilation/provision of NIV (Grade D).
Intubation is indicated in management of AHRF when it is impossible to fit/use a non-invasive interface, for example, severe facial deformity, fixed upper airway obstruction, facial burns (Grade D).
Intubation is indicated where risk/benefit analysis by an experienced clinician favours a better outcome with IMV than with NIV (Grade D).

Outcome following NIV or IMV in AECOPD

Recommendations

Prognostic tools may be helpful to inform discussion regarding prognosis and with regard to the appropriateness of IMV but with the caveat that such tools are poorly predictive for individual patient use (Grade B).
Clinicians should be aware that they are likely to underestimate survival in AECOPD treated by IMV (Grade B).
Clinicians should discuss management of possible future episodes of AHRF with patients, following an episode requiring ventilatory support, because there is a high risk of recurrence (Grade B).

Acute Asthma

Recommendations

NIV should not be used in patients with acute asthma exacerbations and AHRF (Grade C).
Acute (or acute on chronic) episodes of hypercapnia may complicate chronic asthma. This condition closely resembles COPD and should be managed as such (Grade D).

Non-CF Bronchiectasis

Recommendations

In patients with non-CF bronchiectasis and AHRF, controlled oxygen therapy should be used (Grade D).
In patients with non-CF bronchiectasis, NIV should be started in AHRF using the same criteria as in AECOPD (Grade B).
In patients with non-CF bronchiectasis, NIV should usually be tried before resorting to IMV in those with less severe physiological disturbance (Grade C).
In non-CF bronchiectasis, the patient's clinical condition prior to the episode of AHRF, and the reason for the acute deterioration, should be evaluated and used to inform the decision about providing IMV (Grade C).

Good Practice Points

In patients with non-CF bronchiectasis, the precipitating cause is important in determining short-term prognosis.
Health status prior to the episode of AHRF is an important predictor of outcome.

CF

Recommendations

In patients with CF, controlled oxygen therapy should be used in AHRF (Grade D).
In patients with CF, NIV is the treatment of choice when ventilatory support is needed (Grade C).
In patients with CF, specialised physiotherapy is needed to aid sputum clearance (Grade D).
In patients with CF, a mini-tracheostomy combined with NIV may offer greater chance of survival than resorting to IMV (Grade D).

Restrictive Lung Diseases

NMD and CWD

Recommendations

Controlled oxygen therapy should be used in patients with NMD or CWD and AHRF (Grade D).
NIV should almost always be trialled in the acutely unwell patients with NMD or CWD with hypercapnia. Do not wait for acidosis to develop (Grade D).
In patients with NMD or CWD, NIV should be considered in acute illness when vital capacity (VC) is known to be <1 L and RR >20, even if normocapnic (Grade D).
In patients with NMD or CWD, consider controlled ventilation as triggering may be ineffective (Grade D).
In NMD or CWD, unless escalation to IMV is not desired by the patient, or is deemed to be inappropriate, intubation should not be delayed if NIV is failing (Grade D).

Good Practice Points

Individuals with NMD and CWD who present with AHRF should not be denied acute NIV.
NIV is the ventilation mode of choice because patients with NMD or CWD tolerate it well and because extubation from IMV may be difficult.
In patients with NMD or CWD, deterioration may be rapid or sudden, making HDU/ICU placement for therapy more appropriate.
In patients with NMD or CWD, senior/experienced input is needed in care planning and is essential if differences in opinion exist or develop between medical staff and patient representatives.
In patients with NMD, it should be anticipated that bulbar dysfunction and communication difficulties, if present, will make NIV delivery difficult, and may make it impossible.
Discussion about NIV and IMV, and patients' wishes with respect to cardiopulmonary resuscitation, should occur as part of routine care of patients with NMD or CWD.
In patients with NMD or CWD, nocturnal NIV should usually be continued following an episode of AHRF, pending discussion with a home ventilation service.

NIV Failure and Discontinuing NIV following Recovery in NMD and CWD

Good Practice Points

In patients with NMD or CWD, intolerance of the mask and severe dyspnoea are less likely to cause NIV failure. Bulbar dysfunction makes NIV failure more likely.
Deterioration in patients with NMD or CWD may be very sudden. Difficulty achieving adequate oxygenation or rapid desaturation during a break from NIV are important warning signs.
In patients with NMD or CWD, the presence of bulbar dysfunction, more profound hypoxaemia or rapid desaturation during NIV breaks, suggests that placement in HDU/ICU is indicated.

IMV in NMD/CWD

Recommendations

In patients with NMD or CWD, senior staff should be involved in decision-making, in conjunction with home mechanical ventilation specialists, if experience is limited, and especially when the appropriateness of IMV is questioned (Grade D).
Advance care planning, particularly around the potential future use of IMV, is recommended in patients with progressive NMD or CWD. This may best be supported by elective referral to a home ventilation service (Grade D).

IMV Strategy in NMD and CWD

Good Practice Points

Patients with NMD usually require low levels of PS.
Patients with chest wall deformity usually require higher levels of PS.
PEEP in the range of 5 to 10 is commonly required to increase residual volume and reduce oxygen dependency in both patient groups.

Obesity Hypoventilation Syndrome (OHS)

Recommendations

Controlled oxygen therapy should be used in patients with OHS and AHRF (Grade D).
In patients with OHS, NIV should be started in AHRF using the same criteria as in AECOPD (Grade B).
NIV is indicated in some hospitalised obese hypercapnic patients with daytime somnolence, sleep disordered breathing and/or right heart failure in the absence of acidosis (Grade D).

NIV Settings and Placement in OHS

Good Practice Points

High inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP) settings are commonly required in patients with OHS (e.g., IPAP >30, EPAP >8).
Volume control (or volume assured) modes of providing NIV may be more effective when high inflation pressures are required.

NIV Failure in OHS

Good Practice Points

Fluid overload commonly contributes to ventilatory failure in patients with OHS, and its degree is easily underestimated.
Forced diuresis may be useful.
As the risk of NIV failure is greater, and intubation may be more difficult, placement in HDU/ICU for NIV is recommended.

Discontinuing NIV in OHS

Good Practice Points

NIV can be discontinued, as in patients with AECOPD.
Many patients with AHRF secondary to OHS will require long-term domiciliary support (continuous positive airways pressure [CPAP] or NIV).
Following an episode of AHRF referral to a home ventilation service is recommended.

IMV Strategy in OHS

Good Practice Points

In patients with OHS, pressure controlled MV is recommended initially.

In patients with OHS, high PEEP settings may be needed to recruit collapsed lung units and correct hypoxaemia.
In patients with OHS, a forced diuresis is often indicated.

Weaning from IMV

Introduction

Recommendations

Treating the precipitant cause of AHRF, normalising pH, correcting chronic hypercapnia and addressing fluid overload should all occur before weaning is started (Grade D).
A brain natriuretic peptide (BNP)-directed fluid management strategy should be considered in patients with known left ventricular dysfunction (Grade B).

Weaning Methods

Recommendations

Assessment of the readiness for weaning should be undertaken daily (Grade C).
A switch from controlled to assisted IMV should be made as soon as patient recovery allows (Grade C).
IMV patients should have a documented weaning plan (Grade B).

Assessing Readiness for Discontinuation of Mechanical Ventilation

Recommendations

A 30 min spontaneous breathing trial (SBT) should be used to assess suitability for extubation (Grade B).
Factors including upper airway patency, bulbar function, sputum load and cough effectiveness should be considered prior to attempted extubation (Grade D).

Outcome following Extubation

Recommendation

Care is needed to identify factors that increase the risk of extubation failure so that additional support, such as NIV or cough assist, can be provided (Grade B).

Weaning Protocols

Recommendations

Although an organised and systematic approach to weaning is desirable, protocols should be used with caution in patients with AHRF (Grade B).
The use of computerised weaning cannot be recommended in AHRF (Grade D).

Use of NIV in the ICU

Planned NIV to Speed Weaning from IMV

Recommendations

NIV is recommended to aid weaning from IMV in patients with AHRF secondary to COPD (Grade B).
In other causes of AHRF, NIV may have a role in shortening the duration of IMV when local expertise in its use exists (and of cough assist when indicated) and there are features present that indicate extubation is likely to be successful (Grade D).

NIV in High-Risk Patients

Recommendation

Prophylactic use of NIV should be considered to provide post-extubation support in patients with identified risk factors for extubation failure (Grade B).

NIV as 'Rescue' Therapy Post-extubation

Recommendations

NIV should not be used routinely for unexpected post-extubation respiratory failure (Grade B).
In COPD, a trial of NIV may be justified for unexpected post-extubation respiratory failure where local expertise exists (Grade D).

Care Planning and Delivery of Care

Appropriate Care Environments for the Delivery of NIV

Recommendations

NIV services should operate under a single clinical lead having formal working links with the ICU (Grade D).
The severity of AHRF, and evidence of other organ dysfunction, should influence the choice of care environment (Grade C).
NIV should take place in a clinical environment with enhanced nursing and monitoring facilities that are beyond those of a general medical ward (Grade C).
Initial care plans should include robust arrangements for escalation, anticipating that around 20% of AHRF cases should be managed in a level 2 or 3 environment (Grade C).

Good Practice Points

A 2- to 4-bedded designated NIV unit (located within a medical high dependency area or within a respiratory ward with enhanced staffing levels) provides a sound basis for the provision of NIV in a DGH serving a population of 250 000 and with an average prevalence of COPD.
Areas providing NIV should have a process for audit and interdisciplinary communication.

Palliative Care and Advanced Care Planning

Recommendations

Clinicians delivering NIV or IMV should have ready access to palliative medicine (Grade D).
Multidisciplinary advance care planning should be an integral part of the routine outpatient management of progressive or advanced disease and care plans should be reviewed on presentation during an episode of AHRF (Grade D).
The use of NIV may allow time to establish patient preference with regard to escalation to IMV (Grade D).

End of Life Care

Good Practice Points

Although removal of the NIV mask may be agreed as preferable, a dignified and comfortable death is possible with it in place.
Clinicians delivering NIV or IMV should have training in end-of-life care and the support of palliative care teams.

Novel Therapies

Extracorporeal CO_2 Removal ($ECCO_2R$)

Recommendation

If local expertise exists, $ECCO_2R$ might be considered:

If, despite attempts to optimise IMV using lung protective strategies, severe hypercapnic acidosis (pH <7.15) persists (Grade D)
When 'lung protective ventilation' is needed but hypercapnia is contra-indicated, for example, in patients with coexistent brain injury (Grade D)
For IMV patients awaiting a lung transplant (Grade D)

Good Practice Point

$ECCO_2R$ is an experimental therapy and should only be used by specialist intensive care teams trained in its use, and where additional governance arrangements are in place, or in the setting of a research trial.

Helium/Oxygen Ventilation

Recommendation

Heliox should not be used routinely in the management of AHRF. (Grade B)

Definitions

Scottish Intercollegiate Guidelines Network (SIGN) Levels of Evidence

1++	High-quality meta-analyses, systematic reviews of randomised controlled trials (RCTs), or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews or RCTs with a low risk of bias
1-	Meta-analyses, systematic reviews or RCTs with a high risk of bias
2++	High-quality systematic reviews of case control or cohort studies High-quality case-control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal
2+	Well-conducted case-control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal
2-	Case-control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g., case reports, case series
4	Expert opinion

SIGN Grades of Recommendations

A	At least one meta-analysis, systematic review, or randomised controlled trial (RCT) rated as 1++ and directly applicable to the target population *or* A body of evidence consisting principally of studies rated as 1+ directly applicable to the target population and demonstrating overall consistency of results
B	A body of evidence including studies rated as 2++ directly applicable to the target population and demonstrating overall consistency of results *or* Extrapolated evidence from studies rated as 1++ or 1+
C	A body of evidence including studies rated as 2+ directly applicable to the target population and demonstrating overall consistency of results *or* Extrapolated evidence from studies rated as 2++
D	Evidence level 3 or 4 *or* Extrapolated evidence from studies rated as 2+

Good Practice Points: Recommended best practice based on the clinical experience of the guideline

development group.

Clinical Algorithm(s)

None provided

Scope

Disease/Condition(s)

Acute hypercapnic respiratory failure (AHRF) as a complication of chronic obstructive pulmonary disease, acute asthma, cystic fibrosis (CF), non-CF bronichiectasis, restrictive lung disease (neuromuscular disease and chest wall disease), or obesity hypoventilation syndrome

Note: The guideline does not cover the management of AHRF due to cardiac failure, trauma or acute brain injury.

Guideline Category

Management

Prevention

Clinical Specialty

Critical Care

Emergency Medicine

Internal Medicine

Pulmonary Medicine

Intended Users

Advanced Practice Nurses

Emergency Medical Technicians/Paramedics

Hospitals

Nurses

Physician Assistants

Physicians

Respiratory Care Practitioners

Guideline Objective(s)

- To draw attention to the evidence of suboptimal care in acute hypercapnic respiratory failure (AHRF) in the UK, provide an overview of the evidence supporting the use of invasive and non-invasive ventilation, encourage better communication between admitting clinicians and critical care services, promote the use of AHRF patient pathways, and improve resourcing, training, outcomes and patient

experience for all adults who develop AHRF
- To promote integration in the planning and delivery of non-invasive (positive pressure) ventilation (NIV) and invasive mechanical ventilation (IMV) in AHRF

Target Population

Adult patients with acute hypercapnic respiratory failure

Interventions and Practices Considered

1. Principles of mechanical ventilation
    - Modes of mechanical ventilation
    - Choice of interface for non-invasive (positive pressure) ventilation (NIV)
    - Indications for and contra-indications to NIV in acute hypercapnic respiratory failure (AHRF)
    - Monitoring during NIV
    - Supplemental oxygen therapy with NIV
    - Humidification with NIV
    - Bronchodilator therapy with NIV
    - Sedation with NIV
    - Management of NIV complications
    - Management of sputum retention
    - Modes of invasive mechanical ventilation (IMV)
    - Invasive ventilation strategy
    - Application of positive end expiratory pressure
    - Sedation in IMV
    - Minimisation of patient–ventilator asynchrony
    - Use and timing of a tracheostomy
2. Management of AHRF
    - Management of obstructive lung diseases
    - Prevention of AHRF in acute exacerbation of chronic obstructive pulmonary disease (AECOPD)
    - Use of NIV in acute asthma
    - Management of AHRF in non-cystic fibrosis (non-CF) bronchiectasis
    - Management of AHRF in CF
    - Management of AHRF in restrictive lung disease (neuromuscular disease [NMD] and chest wall disease [CWD])
    - Management of AHRF in obesity hypoventilation syndrome (OHS)
3. Weaning from IMV
    - Weaning methods
    - Assessing readiness for discontinuation of mechanical ventilation
    - Planning for outcome following extubation
    - Weaning protocols
    - Use of NIV in the intensive care unit (ICU)
    - Planned NIV to speed weaning from IMV
    - NIV in high-risk patients
    - NIV as "rescue" therapy post-extubation
4. Care planning and delivery of care
    - Appropriate care environments for the delivery of NIV
    - Palliative care and advanced care planning
    - End-of-life care
5. Novel therapies
    - Extracorporeal CO_2 removal ($ECCO_2R$)
    - Helium/oxygen ventilation

Major Outcomes Considered

- Non-invasive (positive pressure) ventilation (NIV) failure rate (need for intubation, death)
- Mortality
- Survival rate
- Quality of life
- Flow rate of supplemental oxygen
- Treatment-associated complications
- Length of hospital/intensive care unit stay
- Ventilator-associated pneumonia

Methodology

Methods Used to Collect/Select the Evidence

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Clinical Questions and Literature Search

Clinical questions were gathered in the PICOT (Patient, Intervention, Comparison, Outcome and Time) format to define the scope of the guideline and inform the literature search (see Web Appendix 1 for search strategy [see the "Availability of Companion Documents" field]). Systematic electronic database searches were conducted in order to identify potentially relevant studies for inclusion in the guideline. For each clinical question, the following databases were searched: Ovid MEDLINE (including MEDLINE In-Process), Ovid EMBASE, EMSCO CINAHL, Ovid PsycINFO and the Cochrane Library (including the Cochrane Database of Systematic Reviews, the Database of Abstracts of Reviews of Effects and the Cochrane Central Register of Controlled Trials).

An initial search was carried out in November 2010, using a combination of indexed and free text terms defining the clinical questions that had been agreed as important in formulating guidelines in acute hypercapnic respiratory failure (AHRF). It was limited to studies after 1990, on adults, in journals published in English and where at least an abstract was available. The searches identified a total of 582 potential papers, which were subsequently supplemented by publications known to members or resulting from additional searches undertaken by the writing groups after 2010. The literature search was run again in September 2013, for relevant publications between 2010 and 2013, yielding a further 308 potentially relevant references. Additional references were subsequently included from personal collections.

Appraisal of the Literature

Appraisal was performed using the criteria stipulated by the Appraisal of Guidelines for Research and Evaluation (AGREE) collaboration. Each paper was appraised by at least two reviewers. The writing lead for each section read the title and abstract of papers identified and agreed with at least one member of each writing group on whether such a paper was definitely relevant, possibly relevant or not relevant, to the section. The criteria used were that the paper addressed a clinical question, the study method used was satisfactory and that the paper was available in English. Review papers and conference abstracts were excluded.

Number of Source Documents

163 studies were ultimately included in the evidence base.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Scottish Intercollegiate Guidelines Network (SIGN) Levels of Evidence

1++	High-quality meta-analyses, systematic reviews of randomised controlled trials (RCTs), or RCTs with a very low risk of bias
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2-	Case-control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g., case reports, case series
4	Expert opinion

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

Appraisal of the Literature

Full papers were obtained for all relevant or possibly relevant abstracts. Two members for each section independently appraised each paper, using the Scottish Intercollegiate Guidelines Network (SIGN) critical appraisal checklists. An evidence level was assigned to each study using SIGN methodology (see the "Rating Scheme for the Strength of Evidence" field). These evidence levels are shown in the evidence tables presented in the online supplementary Appendix 3 (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus

Description of Methods Used to Formulate the Recommendations

Methods and Terminology

The guideline has been produced according to the British Thoracic Society (BTS) Guideline Production manual (see the "Availability of Companion Documents" field) and adheres to the criteria set out in the Appraisal of Guidelines for Research and Evaluation (AGREE II) instrument.

Considered Judgement and Grading of Recommendations

The Guideline Group used the evidence tables to judge the body of evidence and to develop recommendations for this guideline. Where evidence was lacking, expert opinions were obtained by consensus. The following were considered in the grading of the recommendations: the number of studies and number of patients providing evidence, the applicability of such evidence, and whether generalisable to the patient groups in the guideline and to UK practice and the degree of strength as judged by the consistency of evidence obtained to support recommendations.

Recommendations were graded from A to D, using the Scottish Intercollegiate Guidelines Network (SIGN) Grading System (see the "Rating Scheme for the Strength of the Recommendations" field), as indicated by the strength of the evidence as listed in the tables. Important practical points that lack research evidence were highlighted as 'Good Practice Points'. Good practice points are recommended best practice based on the clinical experience of the guideline development group.

Drafting the Guideline

The Guideline Group corresponded regularly. The initial meeting took place in October 2009, and subsequent meetings of the full committee occurred in June and November 2010, September 2011, and March and September 2012. Draft documents were reviewed by the British Thoracic Society (BTS) Standards of Care Committee at meetings in 2013 and 2014, and a final draft was produced with the help and collaboration of members of the BTS Standards of Care Committee in September 2014 to March 2015.

Rating Scheme for the Strength of the Recommendations

Scottish Intercollegiate Guidelines Network (SIGN) Grades of Recommendations

A	At least one meta-analysis, systematic review, or randomised controlled trial (RCT) rated as 1++ and directly applicable to the target population *or* A body of evidence consisting principally of studies rated as 1+ directly applicable to the target population and demonstrating overall consistency of results
B	A body of evidence including studies rated as 2++ directly applicable to the target population and demonstrating overall consistency of results *or* Extrapolated evidence from studies rated as 1++ or 1+
C	A body of evidence including studies rated as 2+ directly applicable to the target population and demonstrating overall consistency of results *or* Extrapolated evidence from studies rated as 2++
D	Evidence level 3 or 4 *or* Extrapolated evidence from studies rated as 2+

Good Practice Points: Recommended best practice based on the clinical experience of the guideline development group.

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

The guideline was made available for public consultation on the British Thoracic Society (BTS) Web site from 7 May to 12 June 2015. The revised document was reviewed by the BTS Standards of Care Committee in September 2015 and final approval for publication was given in November 2015.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The type of supporting evidence is identified and graded for each recommendation (see the "Major Recommendations" field).

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

- Despite evidence demonstrating the value of non-invasive ventilation (NIV) in the management of acute hypercapnic respiratory failure (AHRF), its introduction into routine clinical practice in the UK has not delivered the expected patient benefit and it is likely that NIV provision has, inadvertently, reduced access to invasive mechanical ventilation (IMV) in acute exacerbation of chronic obstructive pulmonary disease (AECOPD) and the other causes of AHRF. The introduction, in hospitals accepting acute admissions, of an adequately resourced and integrated AHRF patient pathway is strongly recommended in the expectation that this will lead to improved clinical outcomes and patient experiences.
- Guidance on the use of sedation within hospitals might be expected to improve patient safety when implemented.

Refer to the evidence statements and discussion sections preceding each recommendation in the original guideline document for a review of benefits and risks of specific recommendations.

Potential Harms

Non-invasive (Positive Pressure) Ventilation (NIV) Complications

The reported rate of complications varies widely. One review gives an incidence between 30% and 50%, the range partly depending on how a complication is defined. Extended duration of NIV, patient agitation and the frequent need to adjust mask fit are all associated with an increase in rate/severity of mask-related problems.
Nasal bridge ulceration is the most common problem (5% to 10%) and may be severe enough to result in NIV failure. Overtightening is a common cause.
Latex allergy occasionally results in florid skin reactions. Some patients seem especially prone to mask-related rash even in the absence of allergy.
NIV may cause severe gastric distension. It usually indicates poor coordination between patient and ventilator and it may be necessary to insert a nasogastric tube.
Sinus or ear discomfort and nasal mucosal congestion or drying/ulceration can all occur.
An acute pneumothorax may be life-threatening but difficult to detect. The development of unexplained agitation/distress or chest pain requires this complication to be excluded. Co-existent interstitial lung disease or previous episodes of spontaneous or ventilator-induced pneumothorax

increase the risk.
Patient agitation and distress are common in acute hypercapnic respiratory failure (AHRF) and may be made worse by the application of NIV before gas exchange has improved and the patient has sensed a reduction in the work of breathing.

Invasive Mechanical Ventilation (IMV) Complications

The adverse consequences of hyperinflation include barotrauma, impaired gas exchange and patient discomfort. The increased intrathoracic pressure impedes venous return and increases right ventricular afterload with a resulting fall in cardiac output and hypotension.
Although sedation increases IMV tolerance, over-use is associated with adverse outcomes such as prolonged duration of IMV, increased intensive care unit (ICU) length of stay and delirium.
Excess fluid administration may delay weaning from IMV or contribute to its failure.

Refer to the evidence statements and discussion sections preceding each recommendation in the original guideline document for a review of benefits and risks of specific recommendations.

Contraindications

Contraindications

Contra-indications for Non-invasive (Positive Pressure) Ventilation (NIV)

Absolute

Severe facial deformity
Facial burns
Fixed upper airway obstruction

Relative

pH <7.15
pH <7.25 and additional adverse features
Glasgow coma score <8
Confusion/agitation
Cognitive impairment (warrants enhanced observation)

Additional Notes on Contra-indications

Vomiting has been considered a contra-indication. The key issue is whether the NIV mask can be rapidly removed, that is, an assessment of whether the patient can signal the need to vomit.

Respiratory arrest or peri-arrest have been considered as absolute contra-indications as NIV is intended to supplement spontaneous breathing. However, as bag and mask ventilation (itself a form of NIV) is used as a prelude to intubation, a short trial of NIV by an experienced operator, can be justified while paying special attention to the risk of glottic occlusion.

In summary, the presence of adverse features is an indication for more intense monitoring and placement within a high-dependency unit/intensive care unit (HDU/ICU) rather than a contra-indication per se.

There are few absolute contra-indications to a trial of NIV but some adverse features, especially when combined, require more caution and more intense monitoring. The presence of adverse features increases the risk of NIV failure.

Refer to the section "Indications for and contra-indications to NIV in AHRF" in the original guideline document for additional discussion.

Qualifying Statements

Qualifying Statements

Healthcare providers need to use clinical judgement, knowledge and expertise when deciding whether it is appropriate to apply recommendations for the management of patients. The recommendations cited here are a guide and may not be appropriate for use in all situations. The guidance provided does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of each patient, in consultation with the patient and/or their guardian or carer.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Implementation Tools

Quick Reference Guides/Physician Guides

Slide Presentation

For information about availability, see the *Availability of Companion Documents* and *Patient Resources* fields below.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

End of Life Care

Getting Better

Living with Illness

IOM Domain

Effectiveness

Patient-centeredness

Identifying Information and Availability

Bibliographic Source(s)

Davidson AC, Banham S, Elliott M, Kennedy D, Gelder C, Glossop A, Church AC, Creagh-Brown B, Dodd

JW, Felton T, FoÃ«x B, Mansfield L, McDonnell L, Parker R, Patterson CM, Sovani M, Thomas L. BTS/ICS guideline for the ventilatory management of acute hypercapnic respiratory failure in adults. Thorax. 2016 Apr;71 Suppl 2:ii1-ii35. [300 references] PubMed

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2016 Apr

Guideline Developer(s)

British Thoracic Society - Medical Specialty Society

Intensive Care Society - Professional Association

Source(s) of Funding

British Thoracic Society

Guideline Committee

British Thoracic Society/Intensive Care Society Acute Hypercapnic Respiratory Failure Guideline Development Group

British Thoracic Society Standards of Care Committee

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Financial Disclosures/Conflicts of Interest

All members of the Guideline Development Group (GDG) made declarations of interest in line with the British Thoracic Society (BTS) policy and further details can be obtained on request from BTS.

ACD declares being paid as a consultant to Smith Medical between 2008 and 2013. ME declares he has received an honorarium, and travel and subsistence expenses for speaking at a meeting in Australia organised by Resmed, a Respiratory Sleep and Ventilation company. He has received an honorarium and travel expenses for speaking at a meeting in London organised by Phillips Respironics, a Respiratory Sleep and Ventilation company. He has received travel and subsistence expenses for speaking at a meeting in China organised by Curative Medical Inc, a Respiratory Sleep and Ventilation company. He has received travel expenses for speaking at meetings in India organised by Phillips Respironics, a Respiratory Sleep and Ventilation company. AG declares being paid as a consultant and receiving honoraria and travel expenses for speaking at meetings organised by Armstrong Medical Ltd in the UK, between 2014 and 2015.

Guideline Endorser(s)

Royal College of Anaesthetists - Medical Specialty Society

Royal College of Emergency Medicine - Medical Specialty Society

Royal College of Physicians - Medical Specialty Society

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Available from the British Thoracic Society (BTS) Web site .

Availability of Companion Documents

The following are available:

British Thoracic Society. Web appendix 1: literature search strategy. London (UK): British Thoracic Society; 2016 Mar. 11 p. Available from the British Thoracic Society (BTS) Web site .

British Thoracic Society. Web appendix 2: evidence tables. London (UK): British Thoracic Society; 2015 Dec 15. 31 p. Available from the BTS Web site .

British Thoracic Society. Web appendix 3: slides. London (UK): British Thoracic Society; 2016 Mar 24. 19 p. Available from the BTS Web site .

Davidson C, Banham S, Elliott M, Kennedy D, Gelder C, Glossop A, Church C, Creagh-Brown B, Dodd JW, Felton T, Foëx B, Mansfield L, McDonnell L, Parker R, Patterson CM, Sovani M, Thomas L. British Thoracic Society/Intensive Care Society Guideline for the ventilatory management of acute hypercapnic respiratory failure in adults. Summary of guideline recommendations. BMJ Open Resp Res 2016;3:e000133. Available from the BMJ Open Respiratory Research Web site .

British Thoracic Society Standards of Care Committee guideline production manual 2016 version. London (UK): British Thoracic Society; 2016. 42 p. Available from the BTS Web site .

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI Institute on July 28, 2016. The information was verified by the guideline developer on September 1, 2016. This summary was updated by ECRI Institute on October 21, 2016 following the U.S. Food and Drug Administration advisory on opioid pain and cough medicines combined with benzodiazepines. This summary was updated by ECRI Institute on February 15, 2017 following the U.S. Food and Drug Administration advisory on general anesthetic and sedation drugs.

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